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Unique Use of Cross-Finger Flap for Reconstruction of an Index Fingertip Electrical Injury

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Unique Use of Cross-Finger Flap for Reconstruction of an Index Fingertip Electrical Injury

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INTRODUCTION

Electrical injuries comprise about five percent of burn admissions in the United States.[1] Through multiple mechanisms, electricity may cause severe injury and is a frequent cause of extremity loss in the setting of high voltage. Due to significant soft tissue destruction, electrical injury generates complex reconstructive needs for limb-salvage, cosmesis, and return of function. This case presents a report of a low-voltage electrical injury resulting in loss of the nondominant index fingertip that necessitated cross-finger flap reconstruction, resulting in an acceptable cosmetic and functional digit.

CASE

A right-hand dominant, 28-year-old electrician suffered electrical injuries to his left index and right small fingers while working with a low voltage (220 volts) electrical source (Figure 1). He was admitted to the United States Army Institute of Surgical Research burn center intensive care unit (USAISR, Fort Sam Houston, San Antonio, TX) due to loss of consciousness for cardiac monitoring and wound debridement. He suffered no complications during his two-day inpatient stay. He followed up in the outpatient clinic weekly and showed evidence of evolution of his left index fingertip electrical injury causing loss of all soft tissue down to the tip of the distal phalanx (Figure 2). The wound was exquisitely tender to manipulation. The options for management, including local wound care, distal phalangeal amputation, and cross-finger flap, were presented to the patient. A decision was made to perform a cross-finger flap due to the relatively normal residual index finger and the patient's desire to maintain as much function for his job as possible.

Under general anesthesia, the left index fingertip was debrided down to healthy, bleeding tissue. Bone of the distal phalanx was present in the wound and was debrided to healthy cortex. Hemostasis was achieved with topical hemostatic agents and needle-tip cautery. A cross-finger flap based on a template of the index fingertip wound was raised, using the dorsal skin of the middle phalanx of the adjacent long finger. The flap was raised above the paratenon and was approximated to the volar index fingertip using interrupted 5-0 nylon suture (Figures 3, 4). A full thickness (FT) skin graft was harvested from the left groin and was used to cover the donor long finger defect using interrupted 3-0 silk tie-over bolster dressing with Xeroform gauze and cotton soaked in mineral oil. The patient was discharged the following day and returned for weekly wound examinations. The tie-over bolster was removed from the FT skin graft of the left dorsal middle finger on postoperative day eight. On postoperative day 21, using a 0.25% bupivicaine digital block for the left index and middle fingers, the cross-finger flap was divided from the left middle finger and inset into the ulnar aspect of the left index fingertip using interrupted 4-0 chromic sutures. The patient had no postoperative complications and returned to full duty as an electrician on post injury day 90 with no complaints and some return of sensation to light touch on the volar aspect of the flap-covered index fingertip (Figure 5).

DISCUSSION

The pathophysiology of electrical injury is complex and not fully understood. The severity of injury to tissue in such cases is a result of the voltage, the amount of current passing through the tissue, i.e. the amperage, the path the current flows along the body, length of contact, resistance of tissue at the point of contact, and individual susceptibility.[1] Voltage can be

quantified and is classified as high-voltage if over 1,000 volts; low-voltage is any number below this value. Typically, indoor electrical injuries in the United States are caused by low-voltage sources. Temperature and thereby tissue injury increase with increases in amperage, which happens over time.[2] Resistance of tissue increases as water content of the tissue decreases. Tissue resistance increases from low levels seen in nerve, blood vessel and muscle, to greater resistance seen in skin, tendon, fat and bone.[1] Tissue in close proximity to bone, especially between bone such as the forearm, tend to retain heat and cause significant tissue injury. Other non-thermal phenomena can result in tissue destruction as a result of electrical injury. Electroporation is the process of pore formation in lipid bilayer membranes due to exposure to a supraphysiologic electrical field.[3-5] Pores allow influx of calcium into the cytoplasm, an event that ultimately triggers cell death.[1] Exposure of cells to an electric field can also result in conformational change of proteins, leading to irreversible degradation, termed electro conformational protein degradation.[6] Although low-voltage injury is much less likely to result in significant tissue destruction, increased contact time may generate enough heat to lead to the pattern of deeper tissue injury, such as seen in the left index fingertip in the case presented. Before any reconstruction is contemplated, the defect has to be well defined. This is especially challenging in any electrical injury but especially when high voltages are involved, as the deficit might not be immediately apparent on presentation.

The goal of any reconstruction is to restore to normal, or as close to normal, form and function. The goal of fingertip reconstruction has been well described and includes preservation of length, motion, durability, sensation and aesthetics. In selecting the appropriate procedure for each individual case, the patient's occupation, comorbid medical conditions, age and hand dominance are all factored into consideration. Multiple options are possible in the reconstruction of a non-dominant index fingertip defect. Completion amputation and shortening has the fastest return to function but this patient desired as much length as possible. Atasoy V-Y advancement of the remaining pulp tissue distal to the distal phalanx crease is another option and would have been ideal if not for the electrical injury.[7] While this local option has the least donor site mobidity, it is often insensate and can only tolerate limited advancement. We considered this option but were concerned that collateral damage to the more proximal microvasculature would make this flap unreliable. Thenar flaps, described for tip defects of the index, middle and ring finger, are possible to bring in uninjured tissue.[8] The disadvantage is an insensate reconstruction and the possibility of late flexion contractures. Free toe pulp transfer is technically possible only in few selected centers across the world and was not considered in this patient but according to published report, represent the best chance for a sensate reconstruction.[9]

A cross-finger flap using dorsal middle finger skin was chosen for this patient. The cross-finger flap is most commonly used to cover type III fingertip amputations.[10-12] It provides a pedicled flap for fingertip defects and requires a noninjured adjacent finger. Advantages of the cross-finger flap compared to other types of tissue transfers for reconstruction of fingertip defects include its larger size and potential for reinnervation. The flap requires immobilization of the injured and adjacent fingers with the potential for development of joint stiffness. To the best of our knowledge, this case is the first reported use of the cross-finger flap for reconstruction of a fingertip soft tissue defect as a result of electrical injury.

CONCLUSION

Electrical injury to the fingertips is common and treatment must be individualized. Delayed tissue necrosis is common and the donor deficit must be defined before the start of reconstruction. Collateral damage to adjacent structures must be considered in selecting an appropriate reconstructive modality. The cross-finger flap technique was chosen in our patient's case due to its benefit as a padded, durable, soft tissue flap with the potential for sensation long term.

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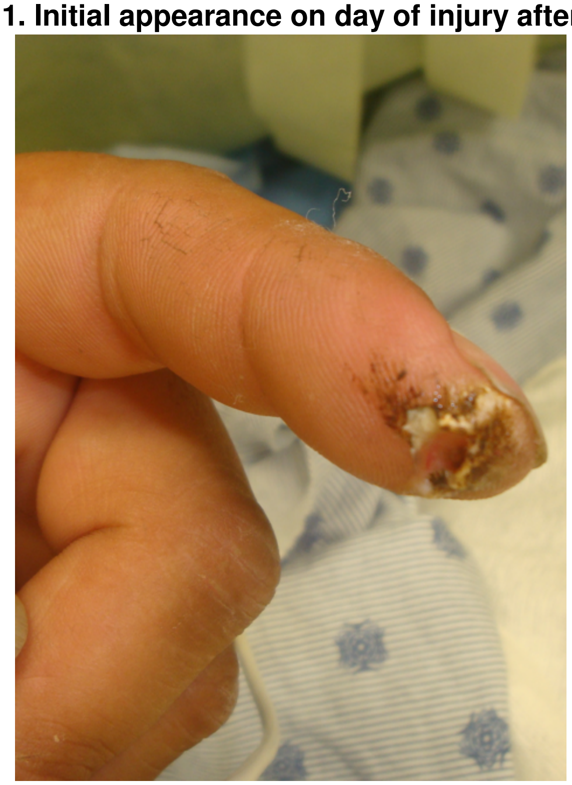
Figure 1. Initial appearance on day of injury after low-voltage electrical contact to left



index fingertip.

Figure 2. Appearance of left index fingertip after evolution of tissue damage; note oblique loss of tip soft tissue.

Figure 3. Cross-finger flap elevated from dorsum of adjacent long finger middle phalanx; note intact paratenon over extensor tendon.

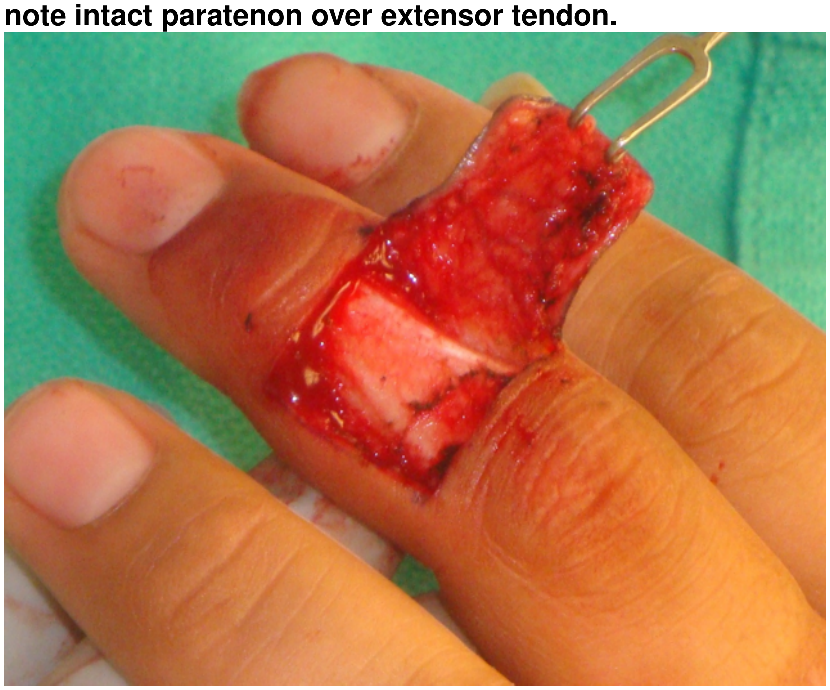


Figure 4. Appearance of implanted cross-finger flap achieving bulky soft tissue coverage of index fingertip defect.

Figure 5. Appearance on post injury day 90; flap has been harvested, all wounds are healed, well vascularized, and patient describes return of sensation to index fingertip.